VESSEL DISTRIBUTION, GROUPING AND FREQUENCY IN THE STEM WOOD OF NEW ZEALAND *Nothofagus* (FAGACEAE) TAXA.

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ABSTRACT

Vessel distribution, grouping and frequency were examined in the stem wood of the four species and two varieties of New Zealand *Nothofagus* namely:- (mountain beech) *N. solandri* var. *cliffortioides* (Hook.f.) Poole., (black beech) *N. solandri* var. *solandri* (Hook.f.) Oerst, (hard beech) *N. truncata* (Col.) Ckn., (red beech) *N. fusca* (Hook.f.) Oerst., and (silver beech) *N. menziesii* (Hook.f.) Oerst.

A distinction was made between solitary vessels, clusters and radial multiples. The number of vessels per cluster and the number of vessels per riadial multiple were recorded. The percentage of vessel clusters was very low, and vessel radial multiples were more abundant than clusters in all five taxa. *N. solandri* var. *cliffortioides* and *N. solandri* var. *solandri* have the highest percentage of radial multiples and the greatest number of vessels comprising a radial multiple. *N. solandri* var. *solandri*, *N. solandri* var. *cliffortioides*, and *N. menziesii* possess more radial multiples than solitary vessels. Not only do *N. fusca* and *N. truncata* have more solitary vessels per unit cross-sectional area, but both taxa have fewer vessels than the other three taxa.

KEYWORDS: vessel distribution, grouping, *Nothofagus*, New Zealand beech.

INTRODUCTION

The five taxa of *Nothfagus* exhibit diffuse porosity (Meylan and Butterfield, 1978). Parham (1930, 1933) distinguished *N. menziesii*, *N. solandri* var. *cliffortioides* and *N. solandri* var. *solandri* from *N. truncata* and *N. fusca*. He observed that the former three taxa possess diffuse porous wood while the latter two taxa show a tendency towards the ring porous condition.

Three types of vessel arrangement are described, these will be defined as: (a) Solitary - a vessel completely surrounded by other cell types. (b) Cluster - an irregular aggregation of vessels in contact with each other, usually about as wide radially as tangentially. (c) Radial multiple - a group of two or more vessels contiguous radially and flattened along the lines of contact (Figure 1) so as to appear as sub-divisions of a single pore (Panshin & de Zeeuw, 1964; I.A.W.A., 1964).

In the literature vessels in multiples are sometimes considered as individual units and sometimes as groups. Because of this a distinction between the total number of vessels per unit cross-sectional area and the total number of groups (units) of vessels per cross-sectional area was made. Here "total number" refers to each vessel as an individual vessel, whether solitary, in a cluster or in a radial multiple.

The objectives of this study were to determine the total number of groups (units) of vessels, the total number of vessels, the number of solitary vessels, the number of clusters, and the number of radial multiples per unit cross-sectional area. The number of vessels per cluster and the number of vessels per radial multiple were also determined.

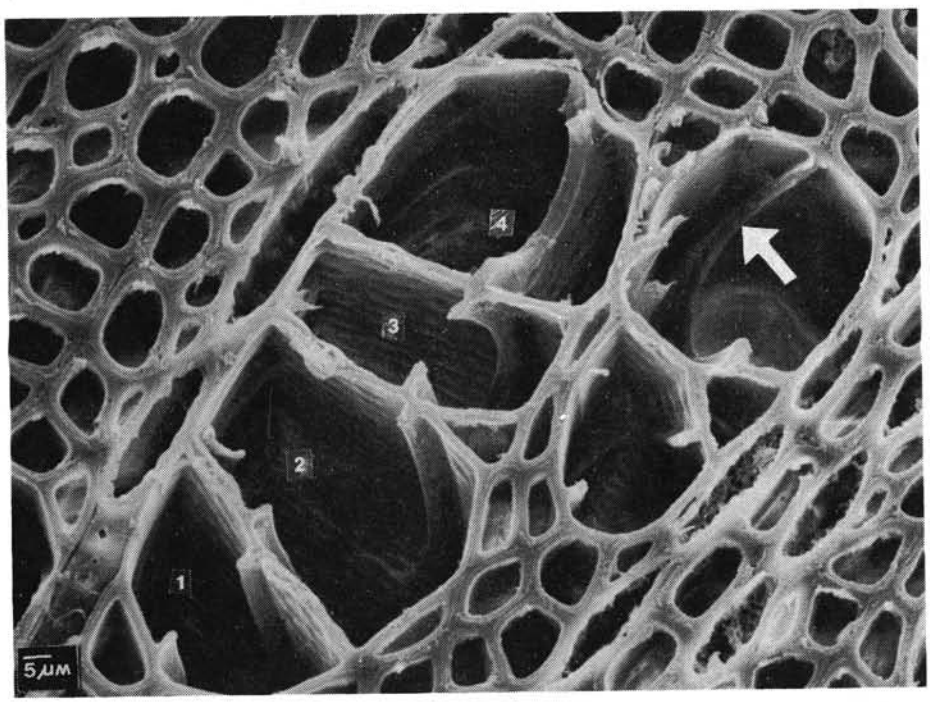

Fig. 1. VESSEL RADIAL MULTIPLES IN *Nothofagus solandri* var. *cliffortioides*.
(Transverse view).
Note the numbered vessels forming a group of four.
Note the steeply inclined perforation plates. (arrowed).

MATERIALS AND METHODS

Random samples were taken between 1-2 metres stem height from beech trees (poles) with approximately 20 cm circumference. Preparation of wood for S.E.M. followed that described by Exley et al. (1973, 1977).

Statistical analyses relate to 25 random trees representing the five taxa. Ten random samples were taken per tree. All counts were made in the early sapwood zone since it is the principle conducting zone.

RESULTS AND DISCUSSION

Examination of more than 1000 micrographs suggests within tree variation is enormous, (Middleton 1985). Figures 2A-E depict representations of each taxon. Table gives the means for each taxon for each type of measurement.

i) TOTAL NUMBER OF GROUPS (UNITS) OF VESSELS PER mm^2.

The results show that *N. solandri* var. *solandri* yields the most vessel groups. An analysis of variance showed that there is no significant difference 'among taxa' but variation 'within trees'.

ii) TOTAL NUMBER OF VESSELS PER mm^2.

The results show that 'intraspecies' variation exists. *N. solandri* var. *cliffortioides* and *N. solandri* var. *solandri* have the most vessels per square mm. An analysis of variance i.e. the 'Random Effects Model' (Sokal and Rohlf, 1981) showed that there is no significant difference between the taxa but the 'within tree' variation is significant.

iii) NUMBER OF SOLITARY VESSELS PER mm^2.

N. truncata has the highest percentage of solitary vessels; 29% of the total. Both Duncan's New Mulitple Range test and the analysis of variance showed no significant difference 'among taxa'.

iv) NUMBER OF VESSEL CLUSTERS PER mm^2.

Vessel clusters form a very small percentage, between 5-8% of the total number of vessels present in each taxon. Statistically there is no significant difference 'among taxa' but significant difference 'within trees'.

v) NUMBER OF RADIAL VESSEL MULTIPLES PER mm^2.

The analysis of variance indicated a significant difference both 'among taxa' and 'within trees'.

NUMBER OF VESSLS PER CLUSTER.

The vessels present in 500 clusters were counted. All taxa have an average of 2-7 vessles aggregated into a cluster. Meylan and Butterfield (1978) noted 2-6 vessels per cluster in *N. truncata* and 2-4 vessels in the remaining beech species.

The analysis of variance showed there is no significant difference between the five taxa means.

NUMBER OF VESSELS PER RADIAL MULTIPLE.

The number of vessels in 2500 radial multiples (500 per taxon) were counted. *N. solandri* var. *cliffortioides*, *N. solandri* var. *solandri* and *N. menziesii* all have an average of 4 vessels while *N. truncata* and *N. fusca* have a mean of 3 vessels per radial multiple. *N. solandri* var. *solandri* had a maximum of 18 vessels comprising a radial multiple.

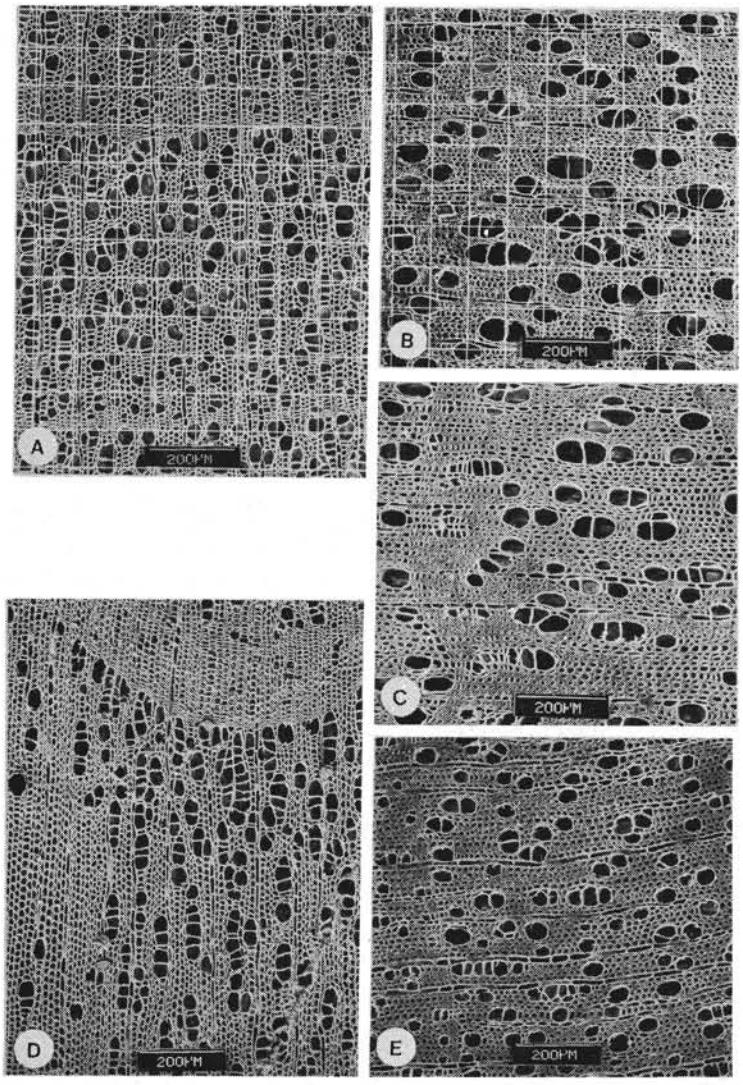

Fig. 2. VESSEL DISTRIBUTION AND GROUPING IN *Nothofagus*

A. *N. solandri* var. *cliffortioides*.

B. *N. fusca*.

C. *N. truncata*.

D. *N. solandri* var. *solandri*.

E. *N. menziesii*.

Table 1. Vessel distribution per square mm. The means for each species of *Nothofagus* is given.

	Total number of groups (units) of vessels	Total number of vessels	Solitary vessels	Vessel clusters	Vessel radial multiples
N. solandri var. *cliffortioides*	112	162	40	16	56
N. solandri var. *solandri*	128	254	56	14	60
N. truncata	108	178	58	14	34
N. fusca	78	164	46	10	22
N. menziesii	104	228	40	14	50

CONCLUSION

In all the taxa, vessels are more frequent in the early wood and sparse in the last few rows of cells in the late wood. Annual rings are variable in distinctness and width. The diffuse porous arrangement may at first glance appear to correlate with those taxa possessing more vessels grouped in radial multiples. But detailed examination shows that although *N. truncata* and *N. fusca* have fewer vessels per unit cross-sectional area than the other three taxa the vessel arrangement nevertheless is diffuse. The author's results agree with Parham's (1933) findings that *N. solandri* var. *cliffortioides* has the greatest number of vessels and *N. fusca* the fewest. However, Parham (1933) deduced that *N. solandri* has half the number of vessels given for *N. solandri* var. *solandri* possess a similar number of vessels.

Middleton (1987) noted pseudo-rays termed aggregate rays in sapling stem wood of all the New Zealand beech taxa except *N. menziesii*. Observations disclose the variation in the distribution of vessels within each aggregate ray zone to be too large to draw any specific conclusion from statistical analyses. Vessels are often absent or concentrated near the growth ring boundary in these zones.

Carlquist (1984) wrote "species with very large vessels at the beginning of growth rings tend to have little grouping in the early wood but more grouping in the late wood". This is consistant in *Nothofagus*. Baas et al (1983) stated "vessel frequency varies tremendously within each ecological category".

Although statistical analyses showed no significant difference in distribution, frequency and grouping within the five taxa and alot of variation within trees some statements can be made.

1. Both *N. solandri* var. *cliffortioides* and *N. solandri* var. *solandri* possess the highest percentage of radial multiples and the greatest number of vessels comprising a radial multiple.

2. *N. solandri* var. *cliffortioides* has the most vessels.

3. The percentage of vessel clusters in all five taxa is low.

4. Solitary vessels are of greatest frequency in *N. truncata* and *N. fusca*.

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